REPORT NO. FGT-1498
DATE: 1 June 1962

HYDRAULICS - FLUID - SPECIFICATION FMS-0006 EVALUATION TESTS

Published and Distributed Under
Contract No. AF33(657) 7248

GENERAL DYNAMICS | FORT WORTH

C O N V A I R
A DIVISION OF GENERAL DYNAMICS CORPORATION
(FORT WORTH)

TEST F-4720
MODEL B-58

REPORT FGT 1498
DATE 16 August 1956

TITLE

HYDRAULICS - FLUID - SPECIFICATION FMS-0006

EVALUATION TESTS

SUBMITTED UNDER

Contract AF-33 (038) 21250

These tests were started 6-23-55 and
Completed 6-1-56

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REFERENCE: FMS-0006
FTDM-1539

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NO. OF PAGES 8
NO. OF DIAGRAMS

REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED

HYDRAULICS - FLUID - SPECIFICATION FMS-0006

EVALUATION TESTS

PURPOSE:

Operating conditions of the B-58 hydraulic system make it mandatory that a new hydraulic fluid be developed for use on this airplane. The fluid needed is one capable of operating under extreme performance conditions as well as at temperatures up to 350°F. Two newly developed silicate ester type hydraulic fluids were considered; Monsanto's OS-45 and Oronite's MLO-8200. MLO-8200 was selected for its better pumping efficiency. However, MLO-8200 shrank and hardened rubber seals at 350°F. To obviate this problem, Oronite submitted their 8515 Fluid, a blend of 85% MLO-8200 and 15% Rohm and Haas's sebacate ester, Plexol 201. The sebacate ester has a swelling effect on rubber which compensates for the shrinking effect of the MLO-8200. The 8515 blend also retains the desirable properties of MLO-8200.

Therefore, the purpose of this test was to determine if Oronite 8515 hydraulic fluid meets the requirements of Convair's Procurement Specification FMS-0006.

SUMMARY:

In order to establish its degree of compliance, Oronite 8515 Fluid was tested as per Convair Specification FMS-0006. Standard procedures were used in most instances. The results were that Oronite 8515 Fluid met the specification with but three exceptions. The first exception, Autogeneous Ignition Point, is minor in as much as it is just below the limit. The other two, Viscosity Change - Oxidation Corrosion test and Compatibility with MIL-O-5606, are more important.

With reference to the Viscosity Change in the Oxidation - Corrosion test, this property increased to the maximum limit permissable under Convair Procurement Specification FMS-0006. This is not desirable since it indicates possible polymerization and formation of large molecules which would lead to a filter-plugging condition.

It has already been shown in FTDM 1539 that the compatibility of this fluid with MIL-O-5606 is questionable. Two percent contamination of Oronite 8515 fluid with MIL-O-5606 could not be tolerated at elevated temperatures.

Shear stability was not investigated due to lack of necessary equipment. No Pesco pump or other suitable pump was available and it was deened unnecessary to purchase one at this time. The aircraft hydraulic pump test and the high temperature operation test were to be run by the Fluid Dynamics Section and the results furnished to us. However, the Fluid Dynamics Section pointed out that no "approved" pump or pump conforming to Convair Specification FZC-4-086 is available now or is likely to be available in the near future. Therefore, they could not be expected to perform these tests. However, performance tests of actual aircraft hydraulic equipment are now in progress.

In discussions, before this test was started, it was agreed by the requestor that vendor data would be accepted for the following items:

1. Compressibility
2. Specific Heat
3. Bulk Modulus
4. Dielectric Strength
5. Thermal Conductivity
6. Toxicity

Although toxological tests were not run here, it was noted that certain toxic effects were evident when working with this fluid. These effects were particularly evident with the fumes produced at elevated temperatures.

HYDRAULICS - FLUID - SPECIFICATION FMS-0006

EVALUATION TESTS

OBJECT: To determine the suitability of Oronite 8515 hydraulic fluid for use in the B-58. Qualification of this fluid is dependent upon its compliance with Convair Procurement Specification FMS-0006.

DESCRIPTION OF MATERIAL:

Oronite 8515 Hydraulic Fluid
Oronite Chemical Company
200 Bush Street
San Francisco, California

Oronite 8515 hydraulic fluid is described as a high temperature hydraulic fluid of the following composition:

79.0% Hexa (2 ethyl-butoxy) disiloxane
15.0% Di-2-ethyl hexyl sebacate
4.0% Methyl ethyl silicone
2.0% pp' dioctyl diphenylamine
0.02% Quinizarin

PROCEDURE: The procedures used in the qualification testing of this fluid were for the most part taken from American Society for Testing Materials, Volume V. Several procedures were taken from Federal Specification VV-L-791-E, 21 May 1953. The remainder of the tests were run according to FMS-0006 or were developed by the Chemistry Section of the Engineering Test Laboratory in instances where procedures were not called out.

The following is a list of the tests and their sources:

1.	Viscosity	ASTM D445-46T
2.	Flash Point	ASTM D92-46
3.	Fire Point	ASTM D92-46
4.	Pour Point	ASTM D97-47

5. Precipitation Number A.S.T.M. D91-40

6. Neutralization Number A.S.T.M. D663-46T

7. Autogenous Ignition Point ASTM D286-30

8. Vapor Pressure, Convair Engineering Test Laboratory, Chemistry Section

9. Specific Gravity, A.S.T.M. D1298-55.

10. Foaming tendency A.S.T.M. D892-46T

11. Storage Stability Convair Procurement Specification FMS-0006

12. Low Temperature Stability Convair Procurement Specification FMS-0006

13. Hydrolytic Stability Convair Procurement Specification FMS-0006

14. Oxidation - Corrosion Stability, Federal Specification VV-L-791E, Method 5308.3

15. Qualitative Evaporation, Convair Procurement Specification FMS-0006

16. Quantitative Evaporation, Convair Procurement Specification FMS-0006

17. Hygroscopic Tendency, Convair Procurement Specification FMS-0006

18. Copper Strip Corrosion A.S.T.M. D130-55T

Some of the required tests, such as; compressibility, specific heat, bulk modulus, dielectric strength, thermal conductivity, toxicity, and shear stability could not be accomplished here and by the consent of the requestor, vendor data has been included in this report.

Since most of the tests were of a standard nature, it is felt that the results are self-explanatory. However, the vapor

pressure method is not standard and was developed from equipment which was available.

The vapor pressure of petroleum oils cannot be sharply defined since these oils are mixtures of organic compounds with a wide variance in boiling range. While the oil under test here is a synthetic oil, it is made up of five different organic compounds, each of which would exert its own vapor pressure. Therefore, it is necessary to treat this oil as a mixture in the same manner as petroleum oils, even though the number of compounds are rather limited in comparison with a petroleum oil.

The vendor suggested a method of obtaining vapor pressure. An attempt was made to duplicate as closely as possible this method and apparatus.

A boiling point type apparatus, immersed in an oil bath, was used in this procedure. The pressure of an inert atmosphere is varied by means of a slow leak, and the vapor pressure of the boiling liquid is taken as equal to the pressure of the inert atmosphere. Provisions were made to measure the pressure by means of a direct connection of a McCleod gauge to the boiling chamber. The temperature was controlled by a variable heater. In this method, the temperature of the liquid is measured rather than that of the vapor phase since accurate temperature measurements in the vapor phase are difficult to make at such low vapor pressures.

The procedure was one in which a weighed amount of test fluid (Oronite 8515 hydraulic fluid) was placed in the boiling point apparatus. A vacuum was applied immediately to degas the sample of absorbed and/or dissolved air. After degassing was completed the pressure was adjusted by means of the slow leak and the temperature was brought up to the boiling point of the test fluid. When it was established that an equilibrium state of pressure and temperature was obtained, the temperature and pressure were recorded. Readjusting the slow leak to obtain another pressure, the entire process was repeated. This was done for a number of pressures and temperatures in order to obtain a temperature - pressure curve.

The apparatus was calibrated using ethyl alcohol. A calibration curve with the determined vapor pressures and the theoretical

vapor pressures taken from Handbook of Chemistry and Physics, thirtieth edition, is included in this report. Corrections were disregarded since they appeared minute in nature and the determined vapor pressure did not approach the maximum permissible limit under this specification.

When the oxidation-corrosion test was done originally, the specification called for only four different metals to be used and the viscosity at 130°F to be determined on the test fluid at the end of the seventy-two hour test period. An amendment put out on 23 January 1956 added another metal and changed the viscosity to 210°F. Due to this change, the test was re-run to conform to a new specification.

A decision was made to re-run the test and several points were brought up concerning the fluid loss during the test and the viscosity increase of the fluid after the test. In order to pin point the cause of these problems, several additional tests were made in which some of the variables were omitted. For instance, in one test, the metals were omitted while the rest of the conditions remained constant. In the other test, both the metals and the air were omitted.

RESULTS: Table I is a complete summary of the tests called out in Convair Procurement Specification FMS-0006, the limits of each test where specified, Engineering Test Laboratory, Chemistry Section data and the vendors data.

Table II is a summary of the work done on the oxidation-corrosion test.

Figure 1 is the calibration curve of vapor pressure vs. temperature of ethyl alcohol.

Figure 2 is the vapor pressure vs. temperature curve of Oronite 8515 hydraulic fluid.

Figure 3 is the specific gravity-temperature relationship of Oronite 8515 hydraulic fluid.

Figure 4 is the kinematic viscosity-temperature relationship of Oronite 8515 hydraulic fluid.

DISCUSSION: In the B-58 airplane, it was evident that MIL-O-5606 petroleum base hydraulic fluids would not meet the temperature

requirements. A search was instituted for a substitute fluid which would meet these requirements, and it was found that a synthetic base fluid, Oronite 8515 hydraulic fluid was the one which was closest to being satisfactory. The purpose of this test was to determine the degree of compliance that was attainable with Oronite 8515 hydraulic fluid. This fluid was evaluated as far as it was possible with available equipment.

As can be seen from the data in Table I, Oronite 8515 hydraulic fluid meets, in general, the limits of Convair Procurement Specification FMS-0006. However, an important part of this specification has been left out and this is the shear stability of the Oronite 8515 hydraulic fluid. The Fluid Dynamics Section of the Engineering Test Laboratory was to perform these tests and supply the data to the Chemistry Section. It was discovered that no "approved" pump or pump conforming to Convair Specification FZC-4-086 was available nor was one likely to be available in time to do the necessary tests. Therefore, no shear data is available and in a hydraulic system such as is to be used in the B-58, with small orifices and high speed pumps, this quality is very important. Any fluid used in such a system must have a low shear rate.

The other points at which this fluid does not meet or is on the borderline of Convair Procurement Specification FMS-0006 are:

1. Autogenous ignition point. This requirement is below the minimum.

2. Oxidation corrosion test. Viscosity Change - This value is right on the top limit. The vapor loss which resulted from this test is questionable, but it has been agreed by different sources that this test may be too severe. Some work has been done by the Materials Laboratory at Dayton, Ohio with the view in mind of reducing the flow rate of air and still retaining the oxidation-corrosion idea of the test.

   As can be seen from our work here, omitting the flow of air reduced the fluid loss. It was unfortunate that time did not permit the determination of intermediate points of air flow, so we would be in a position to correlate the Materials Laboratory's work when it

becomes available. It is evident that vapor loss is dependent upon the air flow and this should not present a problem in a hydraulic system which is sealed.

Another point brought out by the elimination of air flow was the great reduction in viscosity change in the fluid after the oxidation corrosion test. This was anticipated because the viscosity change hinges on fluid loss. Apparently, the metals present catalyze a polymerization in the fluid but it appears necessary also to have a flow of air. When air and metals were removed from the test, viscosity change dropped to a nil value, as did the evaporation loss.

3. Compatibility with MIL-O-5606. This quality is questionable. A complete report has been submitted under FTDM 1539 showing that two percent of MIL-O-5606 could not be tolerated at elevated temperatures. Lesser amounts were questionable therefore it was recommended that no contamination be allowed to occur.

<u>CONCLUSIONS:</u> Oronite 8515 hydraulic fluid meets Convair Procurement Specification FMS-0006 with the following exceptions:

1. Autogenous ignition point.
2. Viscosity Change - Oxidation - Corrosion Test
3. Compatibility with MIL-O-5606. As was mentioned before, vendor data would be accepted for certain parts of this specification.

It was also noticed that while no toxic effects were apparent in handling the fluid itself, the degradation products formed at elevated temperatures caused constriction of the nose and throat.

TABLE I
Oronite 8515
Qualification Tests as per Convair Specification FMS-0006

Tests	FMS-0006 Spec.	Chemistry Lab Data	Manufacturers Data
Viscosity, Cs @ 350°F	3.0 Min	3.70	3.36
Viscosity, Cs @ 210°F	-	9.04	8.11
Viscosity, Cs @ 130°F	-	16.8	-
Viscosity, Cs @ 100°F	-	24.1	24.3
Viscosity, Cs @ -40°F	-	780.0	-
Viscosity, Cs @ -65°F	2500 Max	2300 *	2357
Flash Pt. °F	400	410	410
Fire Pt °F	-	460	450
Precipitation No.	0.0	Nil	0.0
Neutralization No.	0.2 Max	0.02	0.02
Vapor Pressure mm Hg @ 350°F	5.0 Max	0.15	0.20
Specific Gravity @ -65°F/4°C	-	0.9795	0.9820
@ 60°F/4°C	0.905	0.9300	0.9300
@ 350°F/4°C	-	0.8141	0.8090
Foaming Tendency			
Sequence I, 0 min. ml. foam	Determine	480	-
10 min " "	"	0	-
Sequence II, 0 min " "	"	180	-
10 min " "	"	0	-
Sequence III, 0 min " "	"	590	-
10 min. " "	"	0	-
Thermal Conductivity, @ 77°F, BTU/hr/ sq ft/°F/ft	"		0.90
Dielectric Strength, KV	"		-
Bulk Modulus, Adiabatic, PSI	20000 min.		-
Toxicity	No Special Handling		-
Storage Stability, 6 mo's @ ambient	No Separation	Pass	-
Low Temperature Stability, 120 hrs @ -65°F	No Solidification	Pass	Pass
Pump, 500 hrs. @ 160°F, 1500 psi, 3600 rpm	Pass	N.D.	-
Hydrolytic Stability, 48 hrs. @ 200°F			
Copper wt. loss mg/cm²	0.5 Max	0.29	0.03
Appearance of Copper	No Pitting or Corrosion	Pass	Pass
Viscosity Change @ 100°F %	-5 to +15	-7.6	-2.1
Acid No Change %	0.5 Max	0.077	0.10
Acid Content, H_2O Layer, Mg.KOH	10 Max	0.097	0.03
Insolubles, %	0.5 Max	0.18	0.05

*Extrapolated   N.D. = Not Done

TABLE I (Cont'd)

Tests	FMS-0005 Spec.	Chemistry Lab Data	Manufacturers Data
Oxidation and Corrosion, 72 hrs @ 350°F			
Weight Change, mg/cm²			
Steel	+ 0.2 Max	+0.00035	-0.05
Aluminum	+ 0.2 Max	-0.0004	-0.02
Copper	+ 0.4 Max	+0.00005	-0.04
Silver Plated Steel	+ 0.2 Max	-0.00005	-0.04
Magnesium	+ 0.2 Max	-0.0003	-
Appearance of Strips	No Visible Corrosion	Pass	-
Viscosity Change @ 210°F, %	-5 to-20	+ 20	-2.0
Acid No Change %	0.5 Max	0.08	0.5
Insolubles, %	None	None	None
Shear Stability			
Viscosity Change	No greater than MIL-P-5602	N.D.	-
Acid No. Change	0.5 Max	"	-
Evaporation, 4 hrs. @ 350°F	Oily	Oily	-
Evaporation, 6.5 hrs. @ 350°F, %	10 Max	5.98	6.10
Specific Heat @ 300°F, BTU/lb/°F	0.445 Min.		0.47 @ 81°F
Hygroscopic Tendency	Satisfactory	O.K.*	-
Copper Corrosion, 3 hrs. @ 212°F	Pass	Pass	-
Compatibility with MIL-O-5606	Compatible	?	Compatible
Pour Pt °F	-75 Max	Below -87	Below -100
Autogenous Ignition Pt °F	650 Min.	630	760

* [illegible] 25 hours,
100% Relative Humidity, 120°F

TABLE II
Oronite 8515
Oxidation - Corrosion Tests

	FMS-0006 Spec.	Chemistry Data
Oxidation - Corrosion Tests		
72 hrs @ 350°F, 5 Liter Air/Hr		
Weight Change mg/cm²		
Steel	±0.2 Max	+0.00035
Aluminum	±0.2 Max	+0.0004
Copper	±0.4 Max	+0.00005
Silver Plated Steel	±0.2 Max	+0.00005
Magnesium	±0.2 Max	+0.0003
Appearance of strips	No visible Corrosion	Pass
Viscosity Change @ 210°F %	-5 to +20	+20
Acid No. Change %	0.5 Max	0.08
Insolubles	None	None
Evaporation Loss of fluid %	----	10.3
72 hrs. @ 350°F, 5 Liter Air/Hr, No Metals		
Viscosity change @ 210°F %	-5 to +20	+16.7
Acid No. change, %	0.5 Max	0.06
Insolubles	None	None
Evaporation Loss of fluid, %	----	15.7
72 hrs. @ 350°F No Air, No Metals		
Viscosity change @ 210°F, %	-5 to +20	-1.55
Acid No. change, %	0.5 Max	0.05
Insolubles	None	None
Evaporation Loss of fluid, %	----	3.1

Figure 1

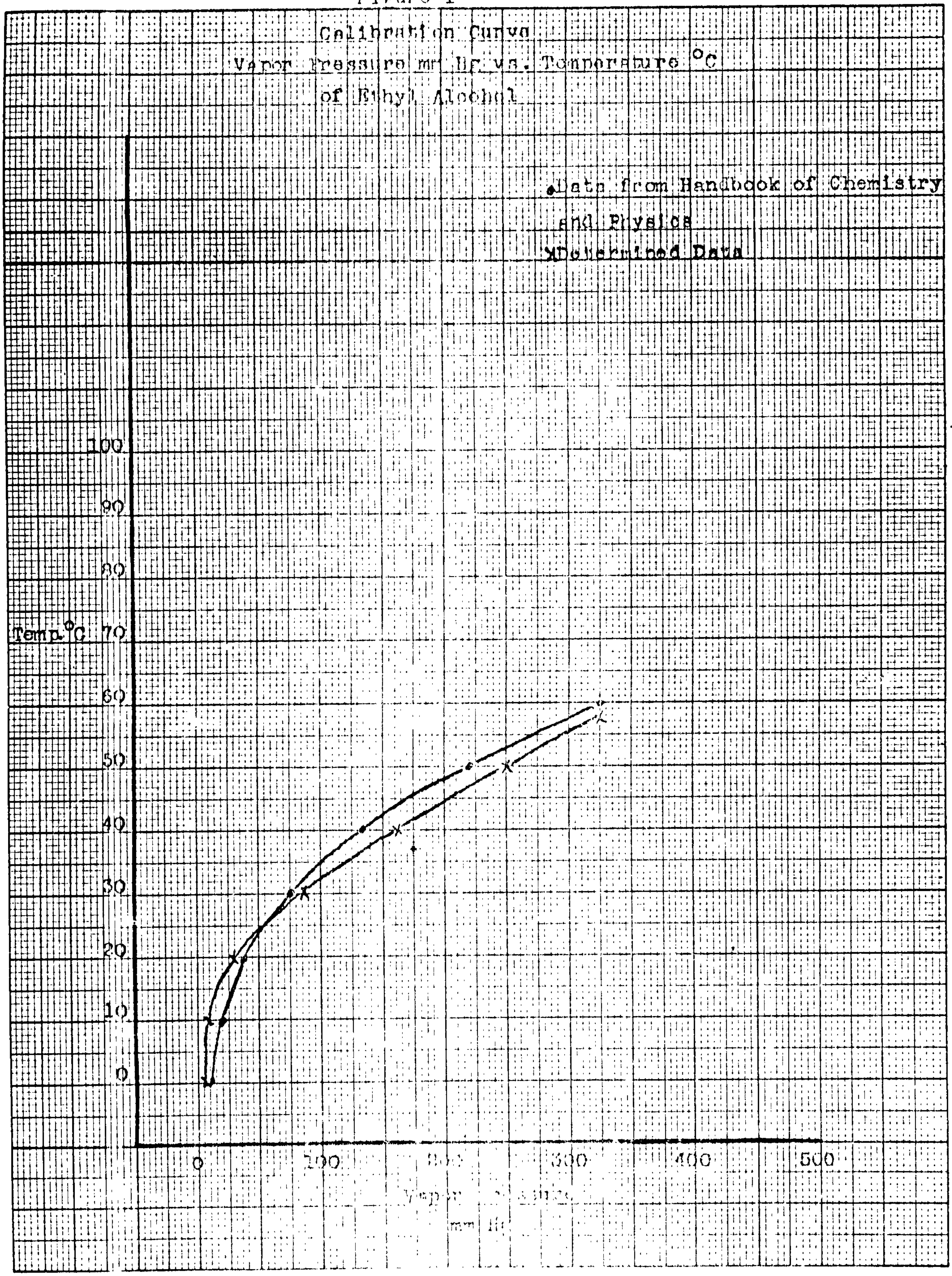

Figure 1

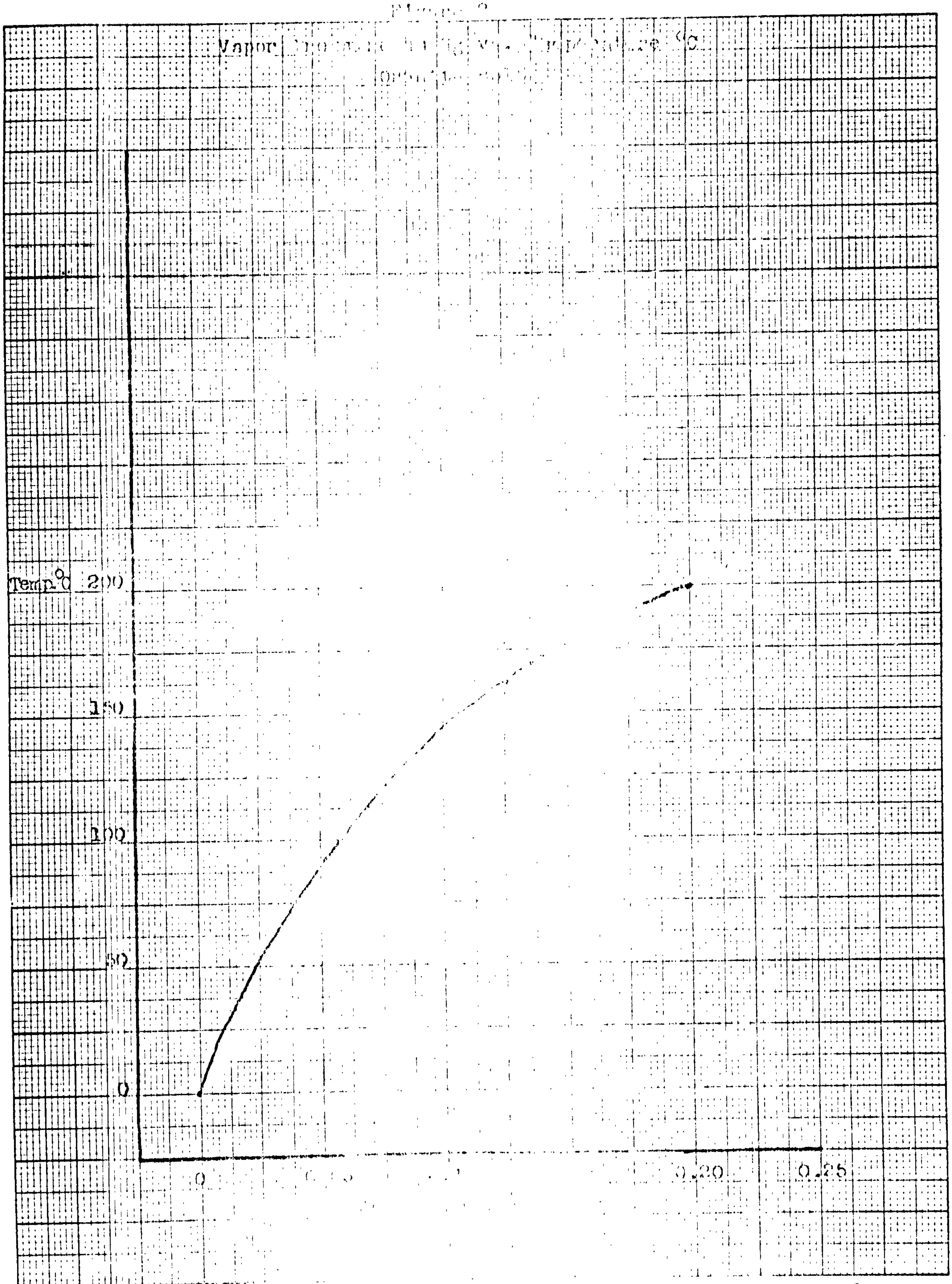

Figure 2

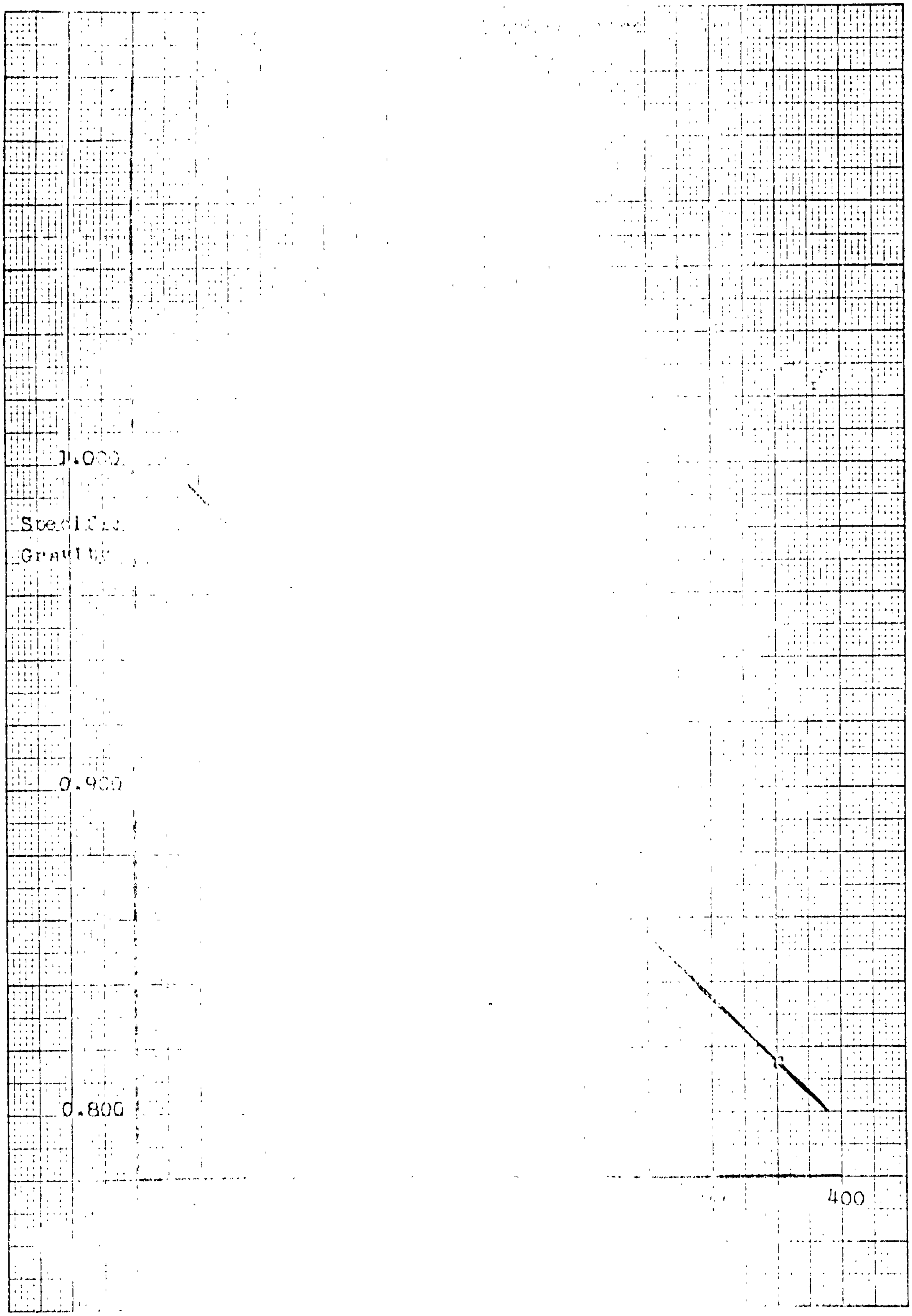

Figure 3

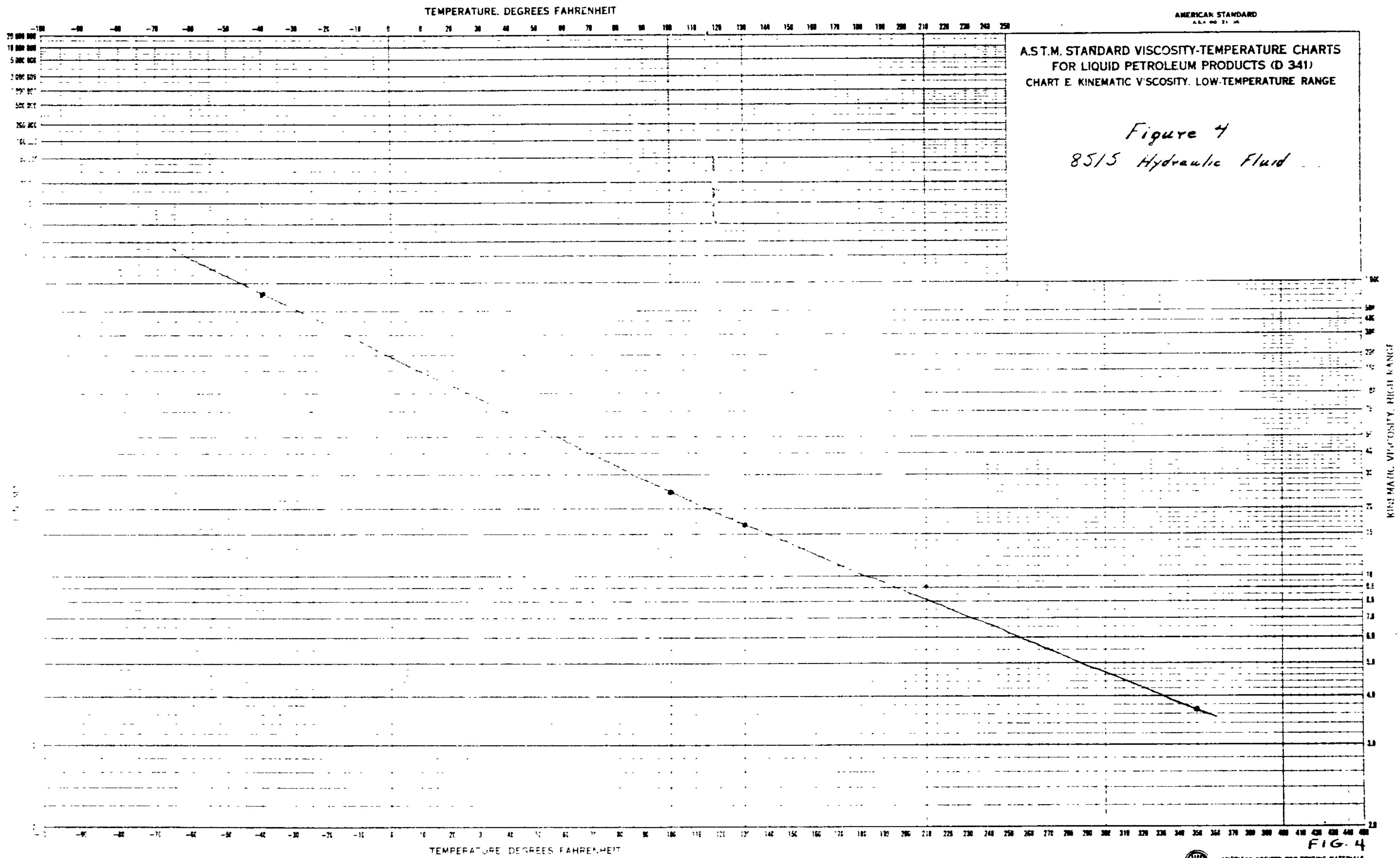
TEMPERATURE, DEGREES FAHRENHEIT
AMERICAN STANDARD
A.S.T.M. STANDARD VISCOSITY-TEMPERATURE CHARTS
FOR LIQUID PETROLEUM PRODUCTS (D 341)
CHART E. KINEMATIC VISCOSITY, LOW-TEMPERATURE RANGE
Figure 4
8515 Hydraulic Fluid
KINEMATIC VISCOSITY, HIGH RANGE
TEMPERATURE, DEGREES FAHRENHEIT
AMERICAN SOCIETY FOR TESTING MATERIALS

FIG. 4